UNIVERSITI PUTRA MALAYSIA

THE APPLICATION OF ELECTRICAL RESISTIVITY IMAGING TECHNIQUE IN THE ASSESSMENT OF STRENGTH PARAMETERS OF RESIDUAL SOIL DERIVED FROM GRANITIC ROCKS

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By

UGANTHARAN MARUTHAVEERAN

Thesis submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Science and Environmental Studies
Universiti Putra Malaysia

March 2000

Dedicated especially to,

Mom and Dad,

my brother Babu,

and

my sister Ammu,

without whose love and continued support

this thesis would not have been possible.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

THE APPLICATION OF ELECTRICAL RESISTIVITY IMAGING TECHNIQUE IN THE ASSESSMENT OF STRENGTH PARAMETERS OF RESIDUAL SOIL DERIVED FROM GRANITIC ROCKS

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Chairman: Dr. Shaharin Ibrahim, Ph.D.

Faculty: Science and Environmental Studies

This thesis reports on the result of an empirical study to use electrical resistivity imaging technique in the assessment of ultimate shear strength of residual soil derived from the weathering product of granitic rock and to identify the depth and lateral extent of possible slip surface of sloping ground located in granitic terrain.

Soil samples were taken from the field and its petrophysical, resistivity and shear strength properties were studied in laboratory. In the field, both electrical resistivity imaging survey and ultimate shear strength probing have been carried out. The result of cross-correlation between ultimate shear strength and resistivity from laboratory and field investigation were integrated to obtain a relationship, which was applied to determine the ultimate shear strength of residual soil from the electrical resistivity inversion data obtained from the study area. The residual soil was derived from the weathering of granitic rock along Kuala Kubu Bahru – Bukit Fraser federal road.

Soil classification results show that the soil at the study area comprised of mainly clayey sand soil of high plasticity index. This study shows that the formation factor, x (i.e the resistivity without the influence of solution salinity in the soil) and the shear strength, y was related by an equation $y = 12.347x^{0.5641}$. The present work also shows that this relationship could only be applied for soil at moisture content between 10% and 50%. The result of field survey and 2-D subsurface imaging, also indicate that the depth of the sliding surface of the failed slope surface was about 1m – 1.5m below ground surface. The boundary between the translated and intact soil was at the ultimate shear strength of about 200kPa.

Therefore it is possible to estimate the ultimate shear strength of the residual soil and to predict the depth and lateral extent of the possible slip surface using electrical resistivity imaging survey at lower cost and wider coverage of survey area.

Abstrak tesis yang dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PENGUNAAN TEKNIK PENGIMEJAN KERINTANGAN ELEKTRIK BAGI PENILAIAN PARAMETER KEKUATAN TANAH BAKI YANG TERBENTUK DARI BATUAN GRANIT

Oleh

UGANTHARAN MARUTHAVEERAN

Mac 2000

Pengerusi: **Dr. Shaharin Ibrahim, Ph.D.**

Fakulti: **Sains and Pengajian Alam Sekitar**

Tesis ini melaporkan hasil dari satu kajian empirikal mengenai penggunaan teknik pegimejan kerintangan elektrik bagi penilaian kekuatan ricih tanah baki yang terbentuk hasil daripada proses luluhawa batuan granit serta mengenalpasti kedalaman serta kelansungan mengufuk permukaan gelinciran yang mungkin terbentuk di dalam tanah baki granit yang cerun.

Sampel tanah telah dikutip dari kawasan kajian dan telah diuji di makmal untuk sifat-sifat petrofizikal, kerintangan elektrik dan kekuatan ricih. Di lapangan, tinjauan pengimejan kerintangan elektrik dan pengukuran kekuatan ricih telah dilaksanakan. Hasil kajian korelasi antara kekuatan ricih dan kerintangan elektrik yang diperolehi dari kajian di makmal dan di lapangan telah diintegrasikan dan kaitan ini telah digunakan dalam penentuan kekuatan ricih tanah baki berdasarkan kepada data songsangan kerintangan elektrik yang diperolehi di kawasan lapangan. Tanah baki yang dikaji

adalah terbentuk daripada proses luluhawa batuan granit di sepanjang Jalan Persekutuan Kuala Kubu Bahru – Bukit Fraser.

Keputusan ujian kelasifikasi tanah menunjukkan bahawa tanah baki dari kawasan kajian adalah terdiri daripada tanah pasir berlempung yang memiliki indeks plastik yang tinggi. Kajian ini juga menunjukkan bahawa hubungan antara faktor formasi, x (nilai kerintangan yang tidak di pegaruhi oleh kandungan garam dalam larutan air tanah) dan kekuatan ricih, y adalah $y = 12.347x^{0.3641}$. Hasil kajian ini menunjukkan bahawa hubungan ini hanya boleh digunakan untuk tanah yang memiliki kandungan air antara 10% - 50%. Hasil dari kerja lapangan dan pengimejan 2-D sub-permukaan, menunjukkan bahawa kedalaman permukaan gelinciran pada permukaan yang gagal adalah kira-kira 1m – 1.5m di bawah permukaan bumi. Sempadan antara tanah yang menggelunsur dan tanah yang utuh adalah pada kekuatan ricih maksimum kira-kira 200kPa.

Kajian ini menunjukkan bahawa teknik pengimejan kerintangan elektrik berupaya menilai kekuatan ricih tanah baki serta menentukan kedalaman dan kelansungan mengufuk permukaan gelinciran yang telah terbentuk pada kos yang rendah dan rantau peninjauan yang lebih luas.

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I am also very grateful to all my dearest friends for their encouragement and help in various ways. Finally, my dearest thanks to my parents, my brother and my sister for their support, care and patience without which this work would never have succeeded.

I certify that an Examination Committee met on 1st March, 2000 to conduct the final examination of Ugantharan Maruthaveeran on his Master of Science thesis entitled "The Application of Electrical Resistivity Imaging Technique in the Assessment of Strength Parameters of Residual Soil Derived from Granitic Rocks" in accordance with Universiti Putra Malaysia (Higher Degree) Act 1980 and Universiti Putra Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

(UGANTHARAN MARUTHAVEERAN)

Date: 27 March 2000

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LIST OF ABBREVIATIONS

AFMAG	Audio Frequency Magnetic Field
DIPIX PLUS	Plotting and contouring of Dipole-Dipole Resistivity and Induced Polarization Data and Profile Data
Eh	A measure of the ability of a system to bring about an oxidation or reduction reaction
EM	Electromagnet
IAEA	International Atomic Energy Agency
IAEG	International Association of Engineering Geology
IP	Induced Polarization
LCD	Liquid Crystal Display
pH	Value taken to represent the acidity or alkalinity of an acqueous solution.
RES2DINV	Rapid 2-D Resistivity Inversion

CHAPTER 1

INTRODUCTION

Overview of Electrical Method Potential

Pressure on natural resources from growing population, with growing demands for water supply, infrastructure and housing has increased in the past decades and can be expected to rise. Further stress on the environment due to pollution will increase the need for detailed geological knowledge for geotechnical, hydrogeological and environment protection purposes. To meet the challenge, earth scientists have developed more and more sophisticated techniques of exploration. The geophysical techniques most widely employed for exploration work are the seismic, gravity, magnetic and electrical methods. Less common methods involve the measurement of radioactivity and temperature at or near the earth's surface and in the air.

The electrical method is one of the youngest geophysical disciplines. Although the first step in applying geoelectrical methods to geology were made more than 100 years ago, the study of geoelectricity only began to develop at the beginning of this century. Electrical prospecting makes use of a large variety of techniques; each based on some different electrical property or characteristics of materials in the